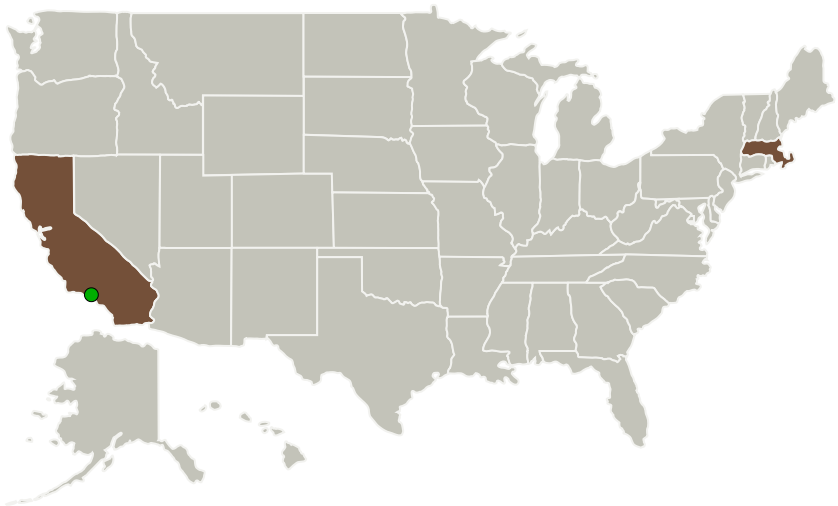
# High Average Power Fiber Laser for Satellite Communications, Phase I

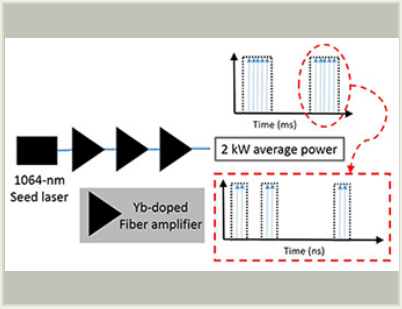
Completed Technology Project (2015 - 2015)

## Project Introduction

Very high average power lasers with high electrical-top-optical (E-O) efficiency, which also support pulse position modulation (PPM) formats in the MHz-data rate speeds, do not currently exist. Solid-state lasers fail to provide the necessary E-O requirements due to low quantum efficiency and excess heat generation. MHz-speed modulation formats are not supported by fiber lasers at very high average powers due to nonlinearities. These nonlinearities cause instabilities in the output power, and also cause the optical spectrum to exceed the system requirements. A very high power, short pulse fiber laser is proposed which can operate in two modes of operation; a targeting/beacon mode, and a data transmit mode. The very high average powers are achieved by filling the time-slot of a PPM format scheme with a high-duty-cycle sequence of much shorter pulses. This allows the nonlinearities in the fiber laser to be mitigated and allow very high average powers within the required bandwidth spectrum. A seed laser which emits picosecond pulses will be driven by electronics to provide a very high duty cycle modulated by a slower modulation envelope to allow for PPM data transmission. The very high duty cycle will allow the average power to increase while keeping the peak powers low through a series of Yb-doped fiber amplifiers. A factor of two is targeted between the peak and average powers. The fiber amplifiers will used highly doped Yb-doped fibers in order to keep the fiber lengths to a minimum, which minimizes nonlinear effects such as stimulated Brillouin scattering (SBS), stimulated Raman scattering (SRS), and self-phase modulation (SPM). The modulation format to support the targeting/beacon mode will be accomplished by turning the final fiber amplifier(s) on/off. This is possible due to the upper state lifetime of the Yb ions in the fiber amplifiers.

## Primary U.S. Work Locations and Key Partners



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## Table of Contents

# High Average Power Fiber Laser for Satellite Communications, Phase I

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| Organizations Performing Work | Role | Type | Location |
|---|---|---|---|
| Q-Peak, Inc. | Lead Organization | Industry | Bedford, Massachusetts |
| Jet Propulsion Laboratory(JPL) | Supporting Organization | NASA Center | Pasadena, California |

| Primary U.S. Work Locations | |
|---|---|
| California | Massachusetts |

## Project Transitions

**June 2015:** Project Start

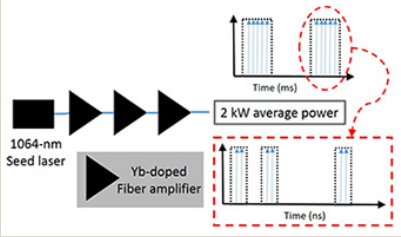
**December 2015:** Closed out

**Closeout Summary:** High Average Power Fiber Laser for Satellite Communications, Phase I Project Image

**Closeout Documentation:**

- Final Summary Chart Image*(https://techport.nasa.gov/file/139043)*

## Images




**Briefing Chart Image**
High Average Power Fiber Laser for Satellite Communications, Phase I *(https://techport.nasa.gov/image/126073)*

## Organizational Responsibility

**Responsible Mission Directorate:**
Space Technology Mission Directorate (STMD)

**Lead Organization:**
Q-Peak, Inc.

**Responsible Program:**
Small Business Innovation Research/Small Business Tech Transfer

## Project Management

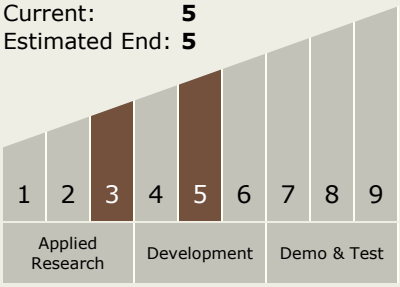
**Program Director:**
Jason L Kessler

**Program Manager:**
Carlos Torrez

**Principal Investigator:**
Ye A Huang

## Technology Maturity (TRL)

Start: **3**
Current: **5**
Estimated End: **5**



# High Average Power Fiber Laser for Satellite Communications, Phase I

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## Technology Areas

**Primary:**

- TX05 Communications, Navigation, and Orbital Debris Tracking and Characterization Systems
  - TX05.1 Optical Communications
    - TX05.1.3 Lasers

## Target Destinations

The Sun, Earth, The Moon, Mars, Others Inside the Solar System, Outside the Solar System